# PILOT STUDY INVESTIGATIONS OF CSEGR

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## RESEARCH OBJECTIVES

Carbon sequestration with enhanced gas recovery (CSEGR) is the process whereby $CO_2$ is separated from fossil-fuel power-plant or industrial-process waste gases, pressurized for transport by pipeline to a depleted gas reservoir, and injected into the depleted gas reservoir to pressurize the reservoir (and sweep $CH_4$ toward production wells) for enhanced $CH_4$ recovery. Although enhanced oil recovery by $CO_2$ injection is an established technology, enhanced gas recovery by $CO_2$ injection has never been attempted. We are carrying out numerical simulations of injecting $CO_2$ into depleted natural gas reservoirs for CSEGR as scoping calculations that will guide selection of a gas reservoir suitable for a pilot study of the injection and gas recovery part of CSEGR.

## APPROACH

We are using a new TOUGH2 module for simulating gas and water flow and transport in gas reservoirs. The simulator handles five components (water, brine, $CO_2$, tracer, and $CH_4$) along with heat and uses the Peng-Robinson equation-of-state model for gas-mixture densities. By Henry's Law, gas species partition between the gas and liquid phases according to their temperature- and pressure-dependent solubilities. We have applied the simulator to investigate pressure response and $CO_2$ transport in a prototypical depleted gas reservoir of area 3.2 $km^2$ (800 acres), thickness 20 m, porosity 0.20, and permeability 1 darcy.

## ACCOMPLISHMENTS

Figure 1 shows the two-dimensional numerical grid and color contours of $CO_2$ mass fraction in the gas phase after one year of $CO_2$ injection, at a total rate of 2 kg $s^{-1}$ (5,740 ton $mo^{-1}$), into two wells (A1 and ME2). This injection corresponds to a relatively high rate if delivery is by tanker trucks (capacity approximately 50 tons, corresponding to nearly 5 truckloads per day per well). As $CO_2$ is being injected, $CH_4$ is being produced equally from wells HJ1, HJ2, and W1 at a total rate of 0.3 kg $s^{-1}$ (41,000 Mcf $mo^{-1}$). The inset of Figure 1 shows the pressure response in bars and mass fraction $CO_2$ in ppm in the observation well (ME1). As shown, the injection rate of $CO_2$ is small relative to the size of the reservoir. Pressure increases, while small, are measurable despite the fact that $CH_4$ is being produced.

## SIGNIFICANCE OF FINDINGS

Simulations of $CO_2$ injection into a depleted natural gas reservoir, carried out with TOUGH2, demonstrate that reservoir pressure maintenance or pressure increases can be produced by $CO_2$ injection with minimal contamination on the time scale of one year. This investigation suggests that larger sources of $CO_2$ (e.g., from an existing pipeline with $CO_2$ intended for enhanced oil recovery) may be a better prospect for the pilot study than $CO_2$ supplied by truck on a smaller scale.

## RELATED PUBLICATION

Oldenburg, C.M., K. Pruess, and S.M. Benson, Process modeling of $CO_2$ injection into natural gas reservoirs for carbon sequestration and enhanced gas recovery, Energy & Fuels 15(2), 293–298, Berkeley Lab Report LBNL-45820, 2001.

## ACKNOWLEDGMENTS

This work was supported by the Assistant Secretary for Fossil Energy, Office of Coal and Power Systems through the National Energy Technology Laboratory, and by Laboratory Directed Research and Development funds at Berkeley Lab provided by the Director, Office of Science, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

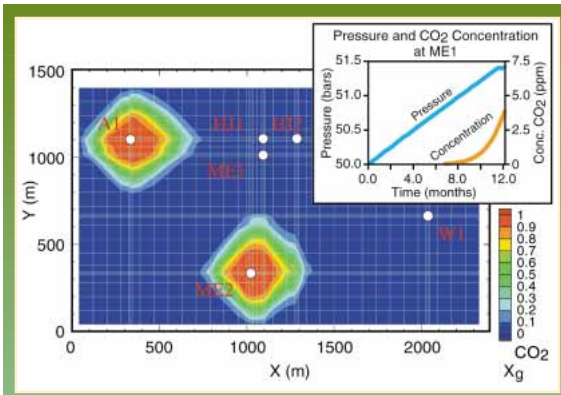


Figure 1. Contours of mass fraction of $CO_2$ in the gas phase after one year of $CO_2$ injection with inset showing pressure and concentration increases over time at the observation well ME1. ([$CH_4$ production is from HJ1, HJ2, and W1]. $CH_4$ Prod. = 0.3 kg/s = 41,000 Mcf/mo. $CO_2$ Inj. = 2 kg/s = 5,740 ton/mo.)